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IN THIS ISSUE

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TEMPERATURE RATINGS AND THERMAL CONSIDERATIONS FOR NUVISTORS

This article describes the basic rules and procedures used to establish temperature ratings for nuvistor valve types. To achieve maximum usefulness and reliability from nuvistors within their published ratings, equipment designers should give careful consideration to the thermal requirements of the valves in the early stages of design. It should be clearly understood that the maximum shell-temperature rating of a nuvistor is not comparable to the maximum bulb-temperature rating of a glass valve. The heat-transfer mechanisms of the nuvistor structure differ substantially from those of a glass valve; the nuvistor is cooled primarily by conduction rather than by radiation and convection. There is no convenient method of directly comparing the nuvistor and glass-valve temperature ratings without exhaustive measurements in a given environment. Although the bulb temperature of glass valves is greatly affected by ambient air temperature, the surrounding air has little effect on the shell temperature of a nuvistor when proper contact between the shell and the chassis is provided by the socket. This statement applies for all normal environments, and also for many abnormal environments involving high packaging density and limited air flow.

Need for Temperature Ratings

Temperature ratings are specified for electron valves to minimize detrimental effects which may reach excessive magnitude if critical temperatures are exceeded. In particular, two physical processes are accelerated as the temperature of electrodes and the surrounding envelope increases: (1) the release of adsorbed or absorbed gases from the envelope and structure, and (2) the emission of electrons from all electrodes, and especially from the control grid. Of these two phenomena, gas evolution is more detrimental to valve life because it tends to destroy emission capabilities of the cathode.

Because the control grid is normally the most negative electrode in an electron valve, it acts as a collector for positive ions produced when gases are released from other electrodes under high temperature. As a result, a variable component of negative grid current may be introduced in the external circuit.

In addition, the control grid is physically near the cathode and normally operates at a relatively high temperature because of radiated heat from the cathode. Any increase in grid temperature enhances the emitting characteristics of the grid and raises the level of primary emission from this electrode. This primary emission then adds another component of negative grid current to the ion current previously mentioned.

The construction and processing techniques used for nuvistor valves involve extremely high temperatures and high vacuum. As a result, the amount of gas liberated from electrodes during normal use is negligible, and thus the value of ion current is negligible. The development of primary emission from the nuvistor control grid is, therefore, the determining factor in establishing the metal-shell temperature rating.

Because the external control-grid circuit for a vacuum valve usually has a high value of resistance, a small change in grid current due to either gas ions or grid emission can lead to a substantial change in the operating point. Both gas and grid-emission currents decrease bias; as a result, dissipation and temperature increase,

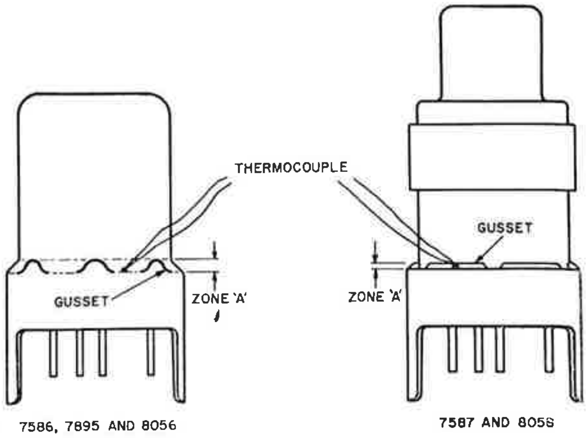

Fig. 1—Sketch illustrating methods of measuring metal-shell temperature of nuvistors.

and a runaway condition may develop. (For example, a 0.1-microampere increase in grid current through a 1-megohm resistor reduces the bias by 0.1 volt. In a valve having high transconductance, a 0.1-volt decrease in bias can cause a 10-per-cent increase in plate current and dissipation.) Similarly, the input impedance will be reduced substantially because of additional grid currents. The effects of grid current, although undesirable, can be greatly minimized in circuit design.

Physical Basis of Temperature Ratings

For a given input power, the maximum bulb temperature of a glass valve is determined primarily by the temperature of the surrounding air because cooling is achieved largely by radiation. Nuvistor valves are cooled primarily by heat conduction through the socket to the chassis. Therefore, chassis temperature rather than air temperature determines the maximum nuvistor metal-shell temperature for a given input power.

The temperature of the control grid in an electron valve is affected by three main factors: (1) radiation from the cathode to the grid, (2) radiation and conduction from the plate to other elements and thus externally through the glass bulb or metal shell, (3) radiation and conduction from external sources to the shell or bulb and thus to internal parts of the valve. Factors (2) and (3) are of primary concern to the circuit designer because they interact to establish the shell or bulb temperature. Furthermore, the circuit designer can control these factors to an appreciable degree.

The ceramic base wafer used in nuvistor valves has very good thermal conductivity as compared to that of glass. This wafer, in conjunction with the metal shell, provides the easiest path for heat transfer by conduction. Radiation from the shell is extremely small. The temperature rise of the nuvistor control grid is determined by the heat radiated to the grid from the cathode and the thermal conductivity of the control-grid structure and base wafer. To establish the maximum grid temperature for stable operation, the nuvistor is rated at the base region of the shell. The term "base temperature" is often used to specify the maximum metal-shell temperature measured in the base region.

Temperature Measurements

The temperature of a nuvistor shell is normally measured at the base of the valve, as shown in Fig. 1. A small thermocouple can be welded into a gusset at the base by discharging a capacitor through the junction of the thermocouple and the metal shell. A 200-microfarad capacitor charged to about 75 volts is suitable for this purpose. An alternate method is to apply commercially available temperature-sensitive paints to the base region, indicated as "Zone A" in Fig. 1.

Socket-Design Considerations

In the conventional JEDEC E5-65 nuvistor socket, heat is transferred from the nuvistor to the chassis by thermal conduction to the socket through metal contacts to the index lugs. Although this socket provides adequate cooling in most applications, much better conduction is achieved through the use of a modified socket (JEDEC E5-79) employing a "fingered" saddle design, as shown in Fig. 2. In this new socket, metal "fingers" bear against the nuvistor shell and facilitate conduction of heat to the metallic saddle.

Plate-Dissipation Ratings and Chassis Temperature

Whenever possible, nuvistors should be located in the coolest region of the chassis. The temperature of the shell should be measured as described

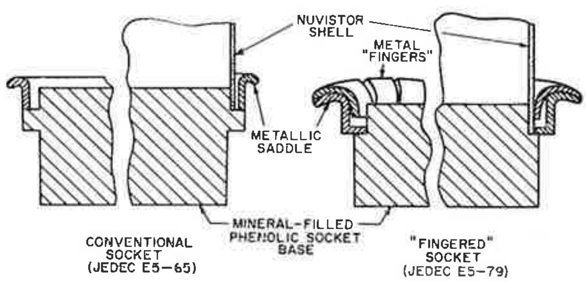

Fig. 2—Conventional nuvistor socket (E5-65) and improved design (E5-79) which increases conduction cooling.

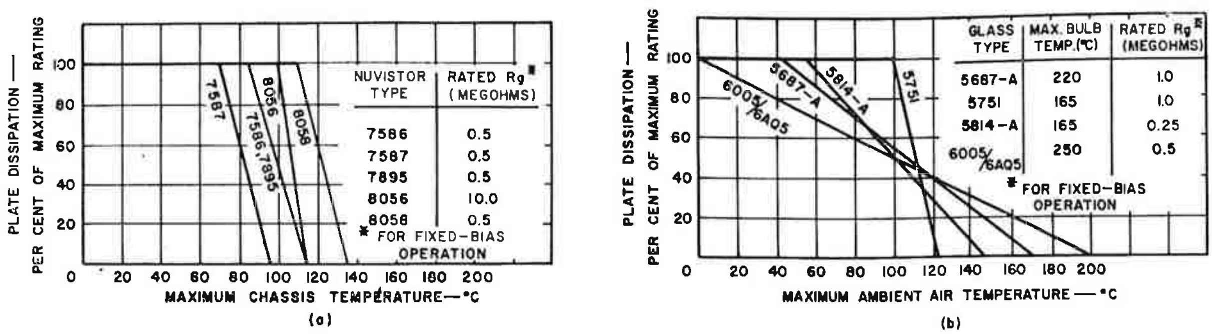

Fig. 3—Curves showing (a) metal-shell temperature of nuvistors as a function of plate dissipation and chassis temperature, and (b) bulb temperature of glass valves as a function of plate dissipation and ambient air temperature.

above to assure operation within ratings. Nuvistors are normally life-tested at a shell temperature of 150 degrees Centigrade. Fig. 3(a) shows combinations of plate dissipation and chassis temperature which produce base temperatures of 150 degrees Centigrade for nuvistor valves operating in conventional sockets under high-line conditions (heater voltage of 6.9 volts). The curves show that type 7587 may be operated at full dissipation and rated grid-circuit resistance at chassis temperatures up to 70 degrees Centigrade, types 7586 and 7895 up to 85 degrees Centigrade, type 8056 up to 100 degrees Centigrade, and type 8058 up to 110 degrees Centigrade without exceeding the maximum metal-shell temperature rating. At higher chassis temperatures, the plate dissipation must be reduced by the indicated percentages to avoid excessive shell temperatures. The chassis temperature limitation at zero plate dissipation is lower than the shell-temperature rating because of a rise in shell temperature due to the heater power.

Fig. 3(b) shows similar bulb-temperature curves for glass valves as a function of ambient air temperatures; these curves were derived from WADC Technical Report 56-53, page 45. The curves are based on the published maximum

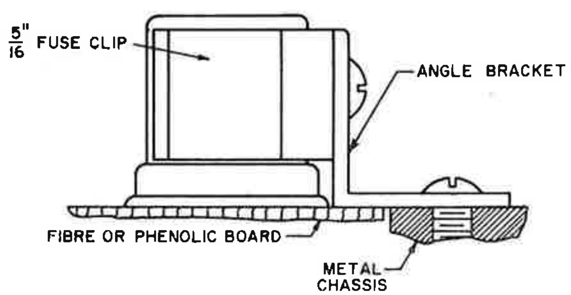

Fig. 4—Sketch illustrating use of heat conducting clamp and metallic heat sink for additional cooling of nuvistors.

bulb temperature for each valve type. When the bulb-temperature rating is exceeded, poor life performance due to cathode poisoning may result. The grid-circuit-resistance value for a particular valve type is rated independently. If the grid-circuit-resistance rating is exceeded, circuit instability may occur independent of the bulb temperature.

Chassis Considerations

The curves shown in Fig. 3(a) apply only to chassis made of materials having good thermal conductivity, such as steel or aluminium. When nuvistors are mounted on a low-conductivity material, such as a phenolic or fibre "printed-board" chassis, less conduction cooling can occur, and heat is also carried away by radiation and convection. On such chassis, therefore, base temperatures are about 50 degrees Centigrade higher than those shown in Fig. 3 unless additional cooling means are used. Fig. 4 shows the use of one type of cooling technique, heat-conducting clamps coupled to metallic heat-sinks.

Table 1 can be used as a rough guide in estimating nuvistor base temperatures for various socket, lead, and chassis combinations. Actual measurements should be made, however, to assure operation within published ratings.

Grid-Circuit-Resistance Ratings

At a maximum shell temperature of 150 degrees Centigrade, published data for the 7586, 7587, 7895, and 8058 specify a maximum value of one megohm for the control-grid-circuit resistance for cathode-bias operation. In the case of type 8056, a 10-megohm resistance is specified. The 150-degree-Centigrade value approximates the typical maximum temperature rating of 85 degrees Centigrade established for most conventional circuit components.

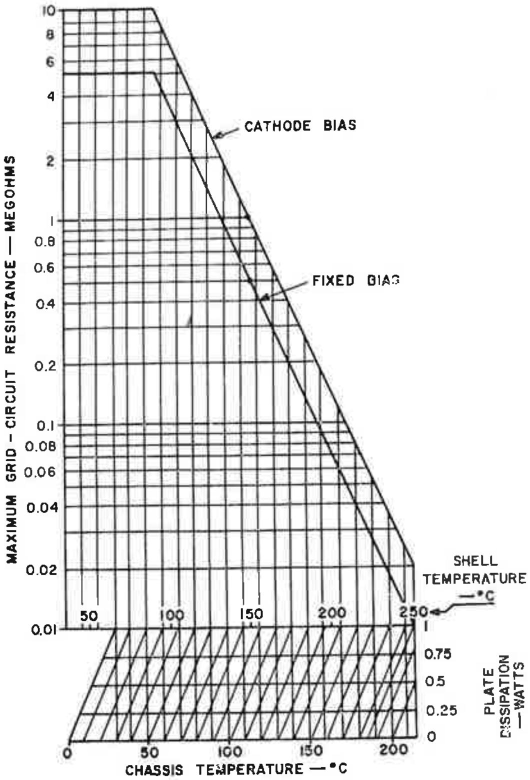

Fig. 5—Nomograph for type 7586.

In many industrial and military applications, chassis configuration and packaging density require operation at chassis temperatures higher than 85 degrees Centigrade. Conversely, in other applications temperature is not a factor, but a larger grid-circuit resistance may be required. Data have been obtained, therefore, to determine the maximum allowable control-grid-circuit resistance for individual nuvistor types at shell temperatures up to 250 degrees Centigrade. These data have been measured in conventional sockets installed on a 1/16-inch aluminium chassis.

The nomographs in Figs. 5 through 9 show the relationship of grid-circuit resistance to chassis temperature and plate dissipation. Any one of these parameters can be determined from the nomographs if the other two are known. For example, if the chassis temperature and plate dissipation are known, the maximum allowable grid-circuit resistance is determined as follows:

First, the intersection of the chassis-temperature and plate-dissipation lines is located on the lower part of the nomograph. A line is then drawn vertically from this point to intersect the

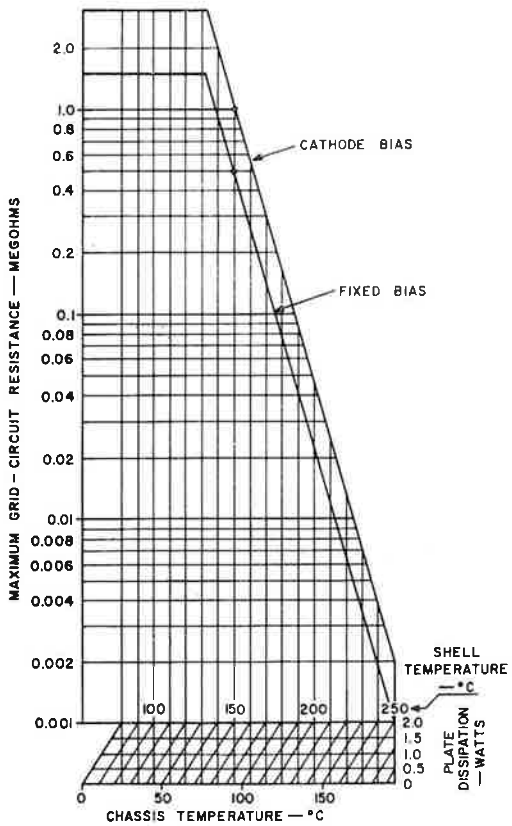

Fig. 6—Nomograph for type 7587.

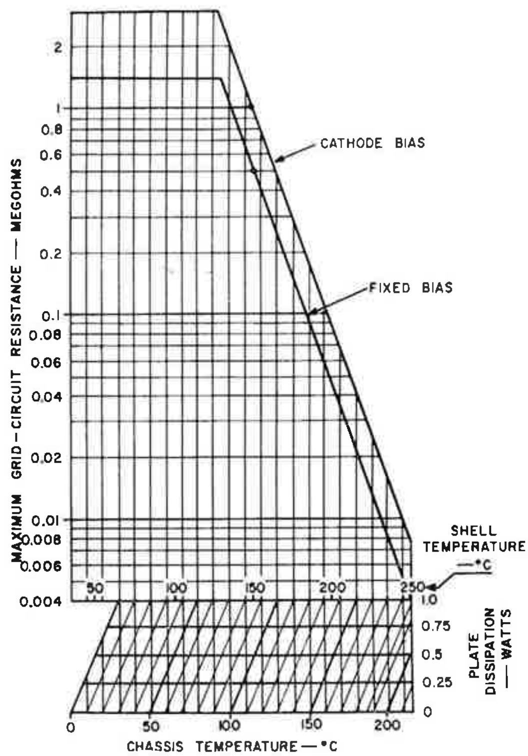

Fig. 7—Nomograph for type 7895.

Chassis Material (1/16" thick)	JEDEC Socket Number	Socket Leads		Base Temperature — °C			
				Nuvistor Triode		Nuvistor Tetrode	
		Wire Size	Length (Inches)	Ef only	1-watt Diss.	Ef only	Max. Diss.
Aluminum	E5-79 E5-65	#16 #16	6 6	45 61	64 94	45 59	75 109
Phenolic	E5-79 E5-65	#16 #16	3 3	65 69	98 105	64 68	107 112

Table I—Nuvistor base temperatures for various combinations of sockets, leads, and chassis. Test conditions: heater voltage Ef = 6.9 volts (high-line condition); chassis temperature adjacent to socket = 25° C.

cathode-bias or fixed-bias line. From this intersection, a line is drawn horizontally to the left to indicate the maximum allowable grid-circuit resistance on the left-hand scale.

Conversely, if the grid-circuit resistance is known, a horizontal line is drawn from this value to intersect the cathode-bias or fixed-bias line. A vertical line is then drawn from this intersection to the lower part of the nomograph. The intersections of this vertical line with the plate-dissipation lines determine the maximum allowable chassis temperatures for given plate dissipations, or the maximum allowable plate dissipations for given chassis temperatures.

As shown in Figs. 5, 8, and 9, the maximum control-grid resistance for types 7586, 8056, and 8058 is 10 megohms. For types 7587 and 7895, it is 3 megohms, as shown in Figs. 6 and 7.

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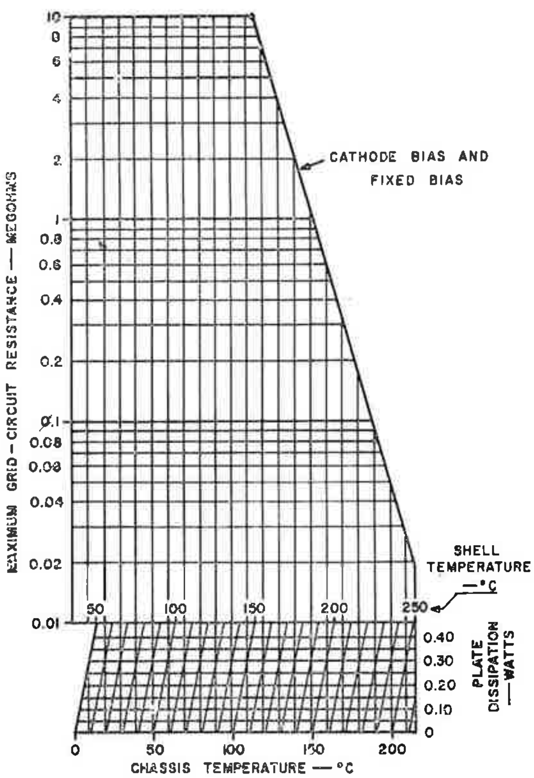


Fig. 8—Nomograph for type 8056.

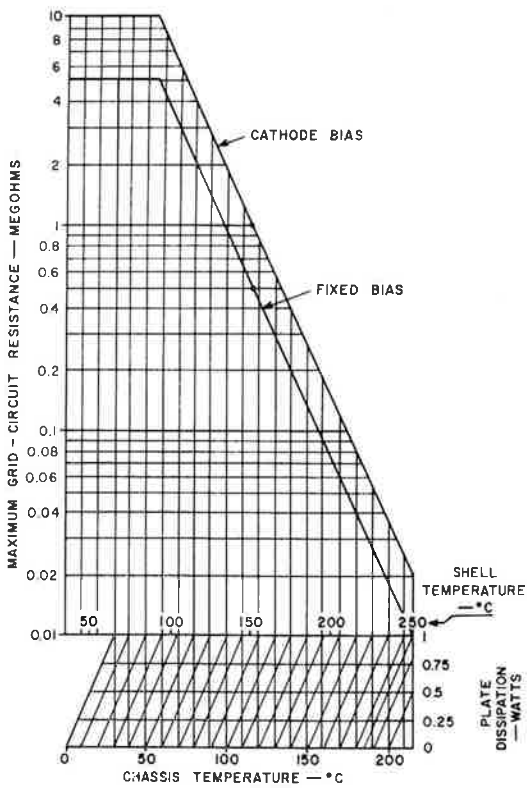
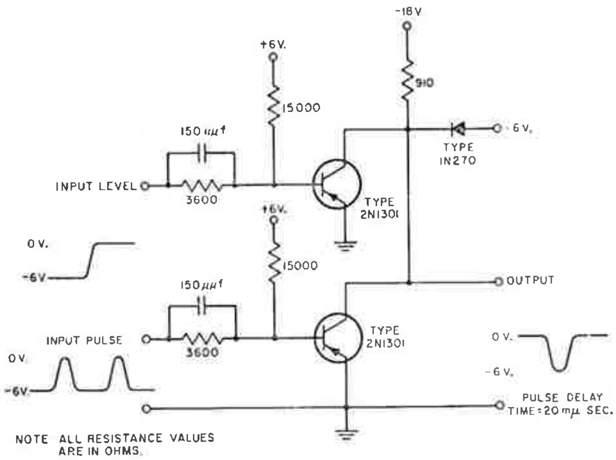
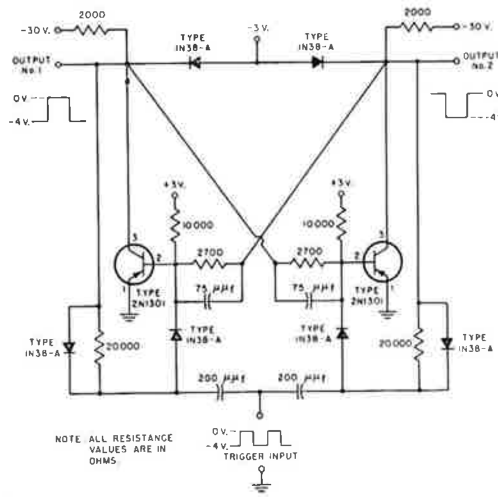


Fig. 9—Nomograph for type 8058.

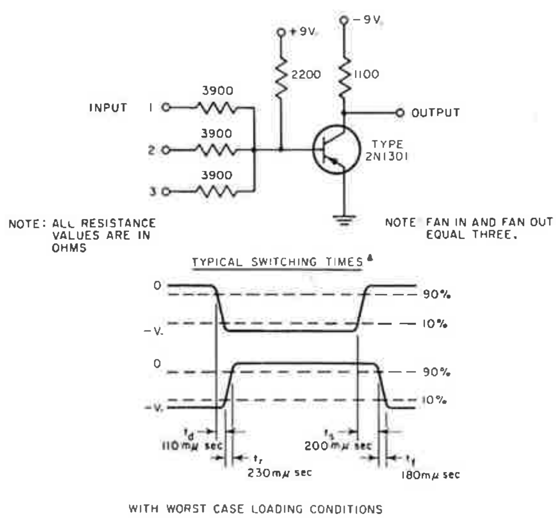
COMPUTER-TRANSISTOR and TUNNEL DIODE APPLICATION CIRCUITS



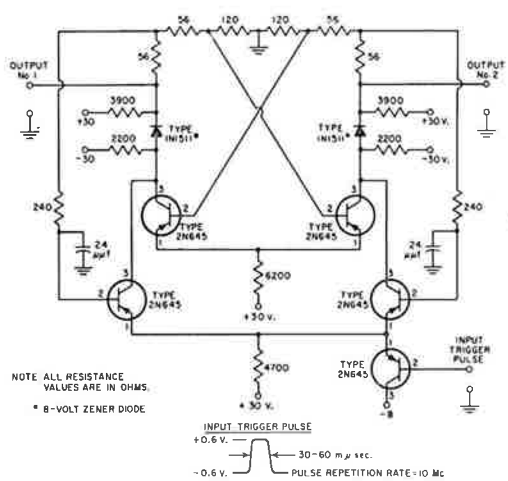
RCTL NAND GATE CIRCUIT
UTILIZING TYPE 2N1301.



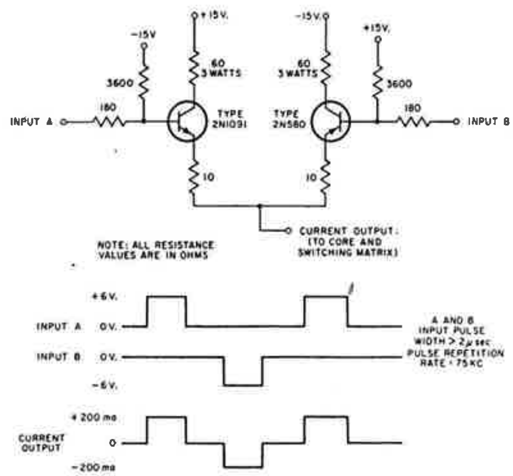
5-MC "FLIP-FLOP" UTILIZING TYPE 2N1301.



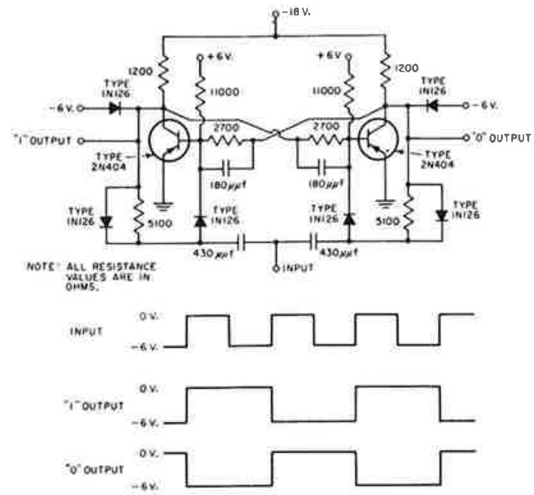
TRL CIRCUIT UTILIZING TYPE 2N1301.



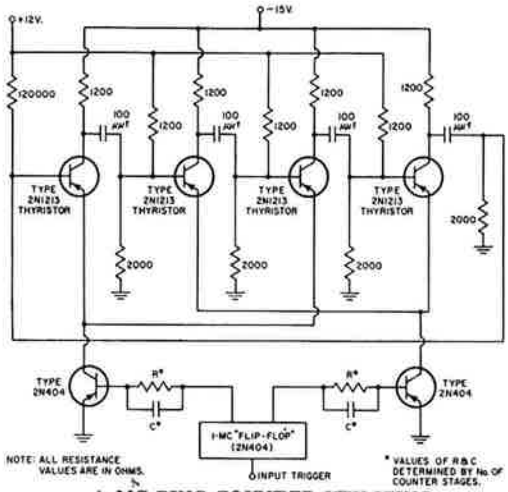
10-MC "FLIP-FLOP" UTILIZING TYPE 2N645.



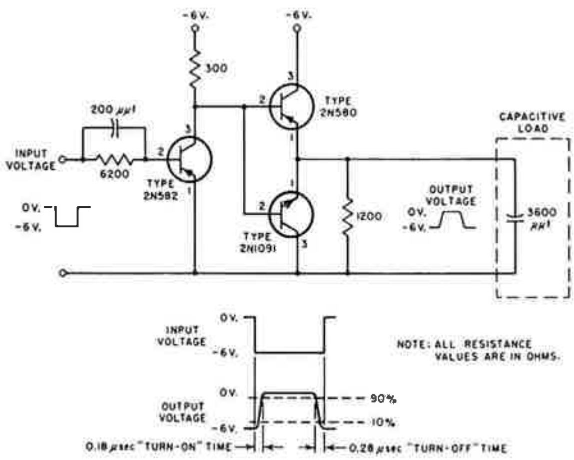
200 MILLIAMPERE CORE - DRIVING CIRCUIT UTILIZING TYPES 2N1091 AND 2N580.



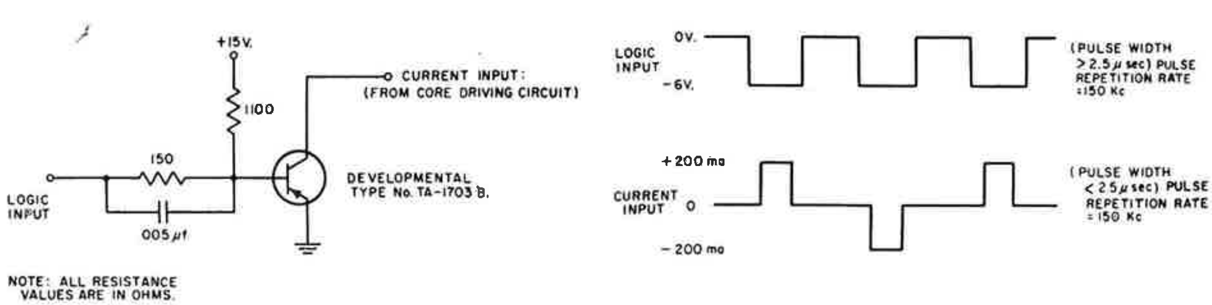
1-MC "FLIP-FLOP" UTILIZING TYPE 2N404.



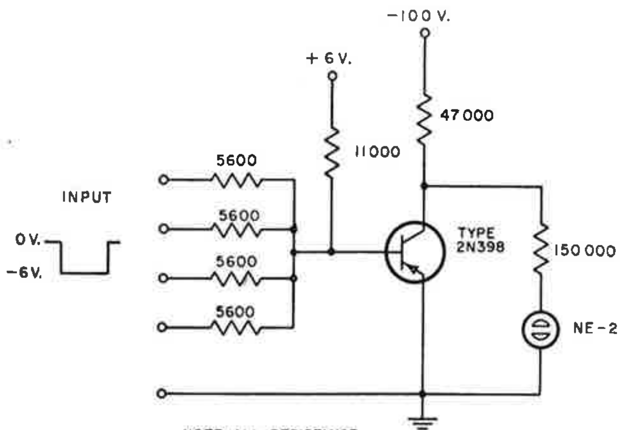
1-MC RING COUNTER UTILIZING TYPE 2N404 and THYRISTOR TYPE 2N1213.



COMPLEMENTARY EMITTER-FOLLOWER CIRCUIT UTILIZING TYPES 2N580, 2N582, AND 2N1091.

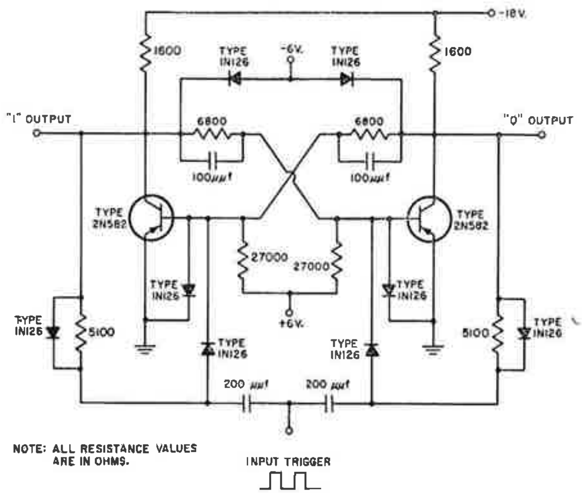


BI-DIRECTIONAL SWITCHING CIRCUIT UTILIZING RCA DEVELOPMENTAL TYPE TA-1703B.

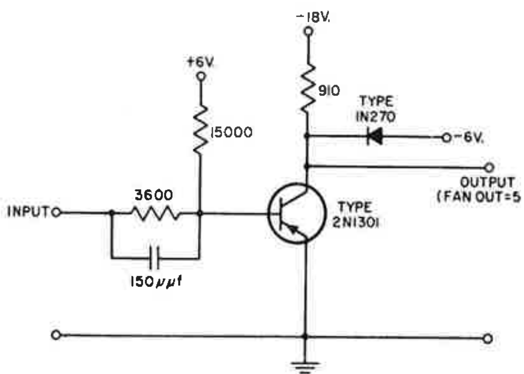


NOTE: ALL RESISTANCE VALUES ARE IN OHMS.

NEON INDICATOR CIRCUIT WITH LOGIC UTILIZING TYPE 2N398.



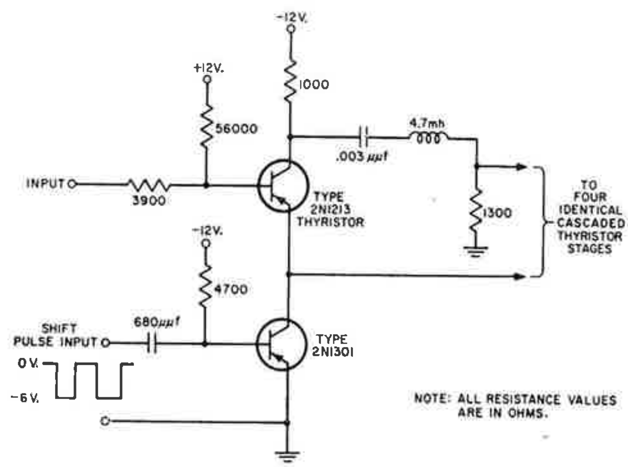
2-MC "FLIP-FLOP" UTILIZING TYPE 2N582.



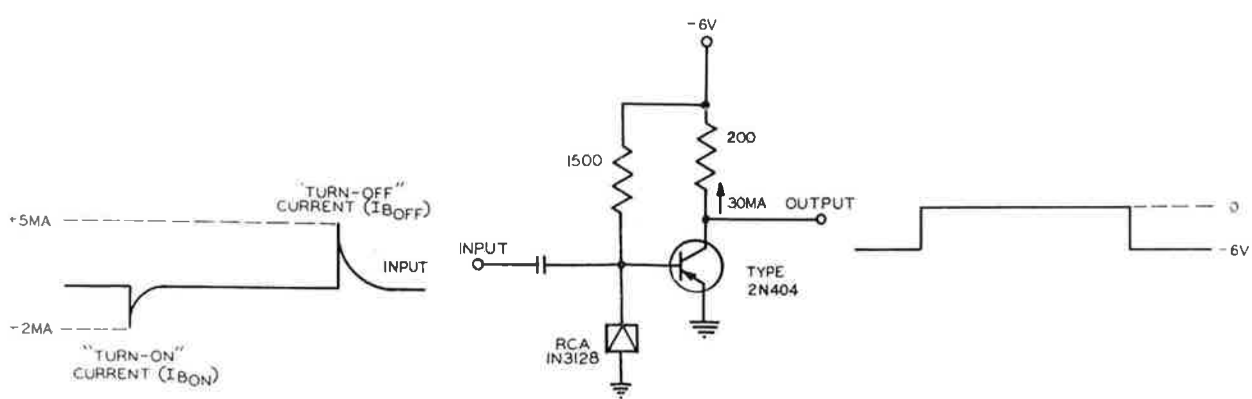
NOTE: PAIR DELAY = 125 mμ sec WITH FAN OUT OF FIVE.

ALL RESISTANCE VALUES ARE IN OHMS.

RCTL BUILDING BLOCK CIRCUIT UTILIZING TYPE 2N1301.

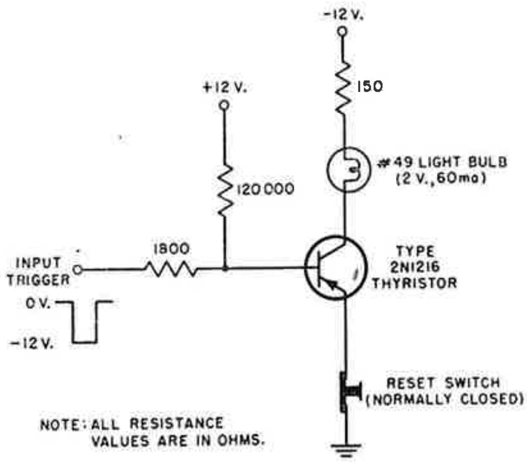


100-KC SHIFT REGISTER UTILIZING TYPE 2N1301 AND THYRISTOR TYPE 2N1213.

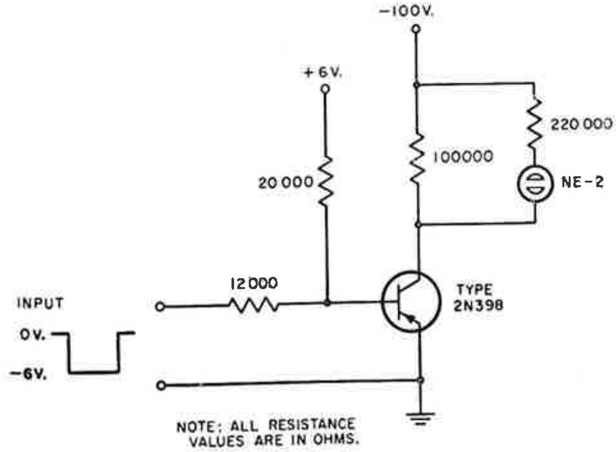


NOTE ALL RESISTANCE VALUES ARE IN OHMS.

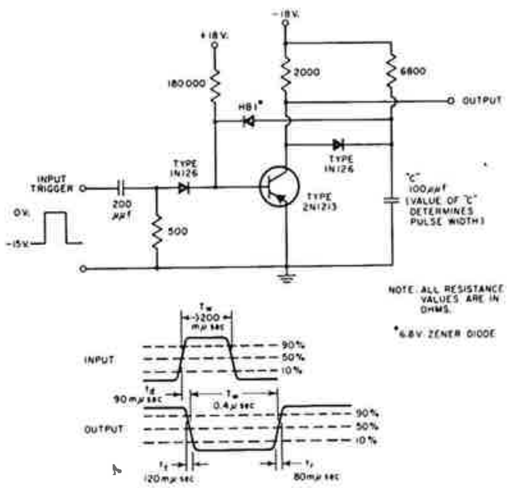
TUNNEL DIODE - TRANSISTOR BISTABLE COMBINATION



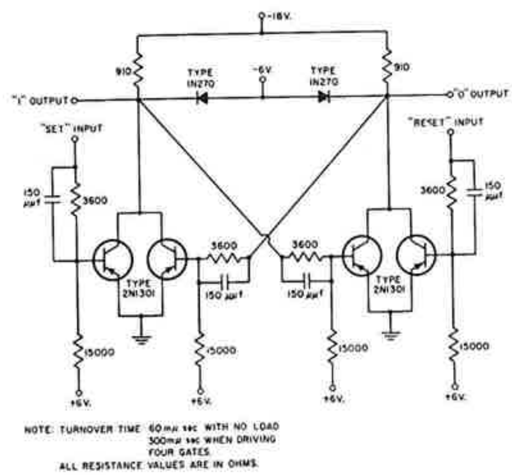
LIGHT BULB INDICATOR CIRCUIT
UTILIZING THYRISTOR TYPE 2N1216.



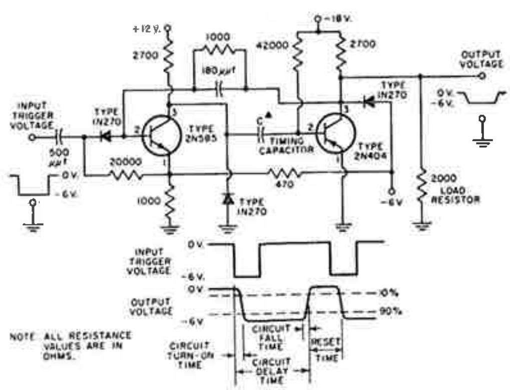
NEON INDICATOR CIRCUIT
UTILIZING TYPE 2N398.



PULSE GENERATOR UTILIZING THYRISTOR TYPE 2N1213.



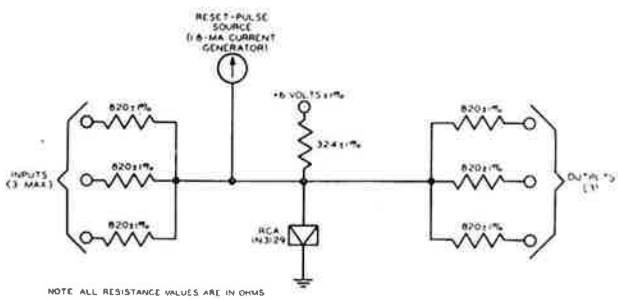
HIGH-SPEED "SET-RESET" "FLIP-FLOP"
UTILIZING TYPE 2N1301.



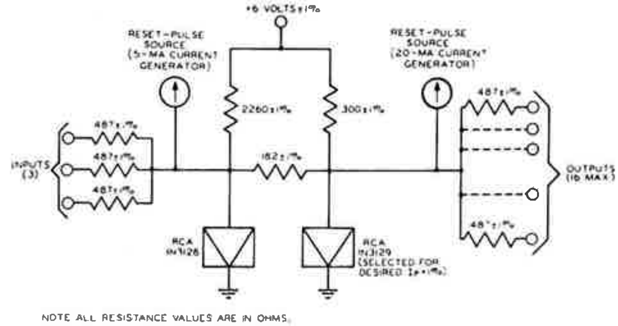
▲ TIMING CAPACITOR μμf	TYPICAL SWITCHING TIMES μsec					
	INPUT TRIGGER VOLTAGE		OUTPUT VOLTAGE			
	Pulse Width	Pulse Rise Time	Circuit "Turn-On" Time	Circuit Fall Time	Circuit Delay Time	Minimum Reset Time
350	1	0.01	0.45	0.8	9	2.7
3400	1	0.01	0.45	2.5	82.5	6.5
7900	1	0.01	0.45	4.2	204	18

COMPLEMENTARY MONOSTABLE MULTIVIBRATOR
CIRCUIT UTILIZING TYPES 2N404 AND 2N585.

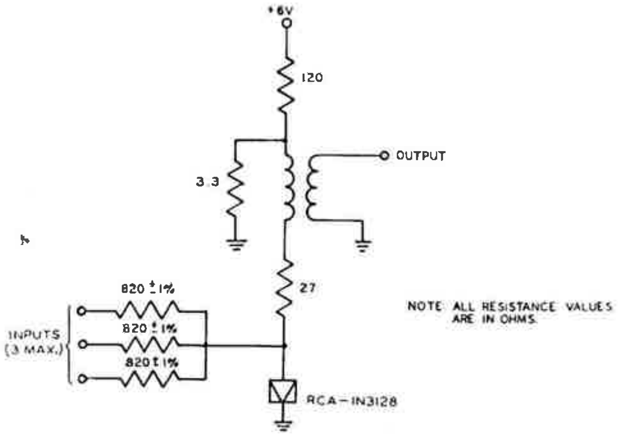
4 ANSWERS to HIGH-SPEED SWITCHING



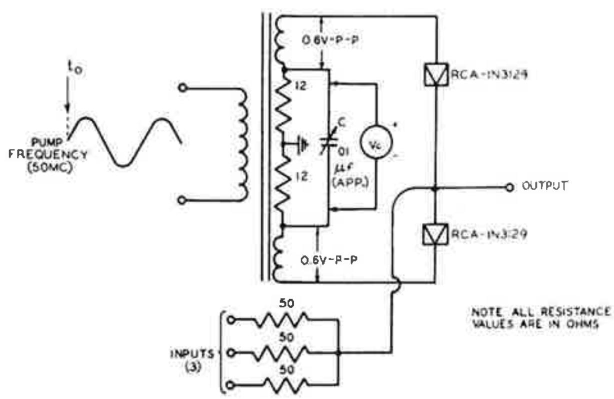
THRESHOLD LOGIC
BISTABLE "OR" GATE WITH RESET



THRESHOLD LOGIC
BISTABLE "AND" GATE WITH RESET



MONOSTABLE "OR" GATE



ADJUST CAPACITOR C FOR A VOLTAGE V_c HAVING THE POLARITY SHOWN AND A VALUE OF 200 TO 250 MILLIVOLTS.
INPUTS MUST BE PRESENT BEFORE t_0 ON PUMP-FREQUENCY WAVEFORM.

MAJORITY-LOGIC
BALANCED-PAIR "AND" GATE

BOOK REVIEWS

Books reviewed in these pages (except AWV publications) are complimentary copies received direct from the publishers. All enquiries for these books should be directed to your local technical booksellers, and not to AWV.

"TELEVISION RECEIVER SERVICING, Volume 2: Receiver and Power Supply Circuits." E. Spreadbury. Second Edition. Iliffe Books Ltd. Size 8¾" x 5½". 475 pages, 274 illustrations in the text.

This is the second edition of the second volume of a comprehensive book (published in two volumes) written primarily for service engineers who wish to obtain a thorough knowledge of television servicing work. It assumes that the reader already has a reasonably good grasp of the principles of radio servicing, and it extends this to the more complex circuits and techniques of television.

Because of the many developments that have taken place since the publication of the first edition, the present one has been completely revised. Among the new material are three additional chapters dealing respectively with TV/FM receivers, printed circuits, and effect on service work of 625-line operation. The present volume now contains nearly 500 pages packed with vital information for the TV service engineer, and sections dealing with such things as press-button and motor-driven tuners and automatic contrast control.

The first volume of this work, which deals with time bases and their associated circuits, was reviewed in these pages in July, 1961. With reservations in respect of local Australian conditions, this work is a valuable one.

"Repairing Home Audio Systems," E. Ecklund, McGraw-Hill Book Co. Size 6¼" x 9¼", 320 pages, index, well illustrated.

As a book on the repairing and adjustment of record players and changers, this title could perhaps merit a place on the bookshelf. Seven of the sixteen chapters deal with changers and their component parts, and they are quite good. The thought occurs however that much more knowledge of the electronic side of home audio systems would be required than is given in this title to operate successfully in the audio field. It may be that standards for this type of thing are different in the U.S.A. In order to operate in the high fidelity field especially, an extensive knowledge of the electronic side of the matter seems very desirable, and one might have expected to find at least a complete chapter on the extended performance testing of such systems. Perhaps this was not intended however, as one gets the impression that what the author is trying to do is to introduce audio repairs to the novice, who in time and with practice may one day become an expert. Viewed as an introductory book to the subject, the matter appears of course in a different light.

"High Quality Sound Production and Reproduction," H. Hadden, Iliffe Books Ltd., by arrangement with the BBC. Size 8¾" x 5½", 274 pages, 175 diagrams plus 46 pages of plates, with index and bibliography.

This title is a BBC programme operations training manual, and it is therefore inevitable that the whole slant of the book should be towards broadcasting station practice and considerations. The book would therefore prove more useful to broadcasting and similar bodies than to audiophiles and the like. The book is essentially a practical title, in that after the necessary introductory chapters on sound, acoustics and basic electrical theory, the author plunges into very informative chapters on the placement and use of the complex of equipment one finds in the modern broadcasting station. One other group that could be interested in this title consists of those who are very active in the P.A. and sound reinforcement fields.

"ELEMENTS OF ELECTRONIC CIRCUITS: Building Bricks for Circuit Design." J. M. Peters. Iliffe Books Ltd. Size 10" x 7½". 98 pages, with 131 diagrams in the text.

Any complex electronic circuit can be built up from a number of elements each with its own specific function. Information on such elements is to be found scattered throughout technical literature; searching for it is both time consuming and annoying. Here in one volume is a selection of those in most frequent use, grouped together for ease of reference.

"ELEMENTS OF ELECTRONIC CIRCUITS" is based on a series of articles which appeared as a regular feature in "Wireless World." It is written in simple language, with a minimum of mathematics and an emphasis on physical explanations. The book is heavily illustrated with large, clear line diagrams, prominent features of which are the input and output waveforms. With its comprehensive bibliography and index, this book will prove invaluable as a source of reference for professional engineers, whether used on the laboratory bench or office desk, and as an instruction manual for students and service technicians.

"SQUARE-LOOP FERRITE CIRCUITRY: Storage and Logic Techniques." C. J. Quartly. Iliffe Books Ltd. Size 8¾" x 5½". 166 pages, including 92 diagrams in the text.

Initially the development of high-speed computers was seriously handicapped by the lack of a suitable method of storing information, but this situation was changed by the discovery of a ferrite with a rectangular hysteresis loop, which fulfilled the main requirements of reliability, cheapness and speed of obtaining information. Since transistors of the required characteristics have become available, the associated circuits have advanced rapidly.

The author describes in a concise and simple manner the principles of operation of coincident drive stores and more elaborate systems which have been proposed to increase speed of operation. Though primarily intended for matrix stores, square-loop ferrite cores have found other uses in computers and the other digital equipment, and brief descriptions are given in this book.

This book will serve as an introduction for engineers who are beginning work on square-loop circuits, and also as a source of information for anyone concerned with the development, maintenance and use of such systems.

"Electron Devices and Circuits," J. M. Carroll, McGraw-Hill Book Co. Size 6¼" x 9¼", 344 pages, with index and bibliography, well illustrated.

The author of this new book is the Managing Editor of the magazine "Electronics," which disposes very neatly of the author's qualification to write such a book. It leaves nothing to be said except about the book itself. This title consists of an introductory volume to electron devices of all types, ranging from simple electron valves through the more exotic types and into the world of semiconductors. In many respects the introduction is more thorough than one might expect, not only in the field of coverage, which includes masers, lasers and parametric amplifiers, magnetic amplifiers and self-sustained emission tubes, but in the foundation of basic principles laid down early in the book.

The introduction into the argument of such factors as quantum energy, and an outstanding chapter on the atomic basis of electron devices, shows the effort made by the author to make sure that the reader has as complete an understanding of the subject as the scope of the book permits. This title would be suitable for use as a basic text at the technician and undergraduate level.

"Radio-Electronic Transmission Fundamentals," B. Whitfield Griffith, Jnr., McGraw-Hill Book Co. Size 6¼" x 9¼", 612 pages, with index and test questions.

To use the word "fundamentals" in the title of this new book was perhaps to understate the situation. This book is offered as a study course in the generation and handling of high-power radio frequency energy, and goes far beyond fundamentals as the word is generally understood. The 68 chapters in this title are divided into four sections, dealing respectively with Electrical Networks, Transmission Lines, Radio Antennas and Radio Transmitters. Although the presentation of the material is based upon the philosophy of advanced knowledge, it is clearly expounded and easily understood. Mathematics are introduced as required, but higher mathematics are avoided where possible, the author using instead approximations in mathematics and logic. This device lends clarity to the discussion, and makes this book useable and useful to students at the technician and higher levels. It is for example an excellent possibility for any of the more studious "Hams" or anyone else particularly interested in transmission to advance his knowledge of the subject.

TRANSISTOR POWER SUPPLY No. 2

by B. J. Simpson

Introduction

Earlier this year, in the January issue of this magazine, we published a circuit for a transistor power supply. That unit had an output of up to 15 volts at a maximum current of 4 amperes. No overload protection was included.

Although many of those units have been made up and successfully brought into service, enquiries have also been received for a smaller and cheaper unit with a lower power rating. All of these requests have been carefully considered, and this unit is the result.

The Formula

Several approaches were made to this problem with a view to finding the optimum solution, both from an operating point of view, and from an economic aspect. Several trial circuits were mocked up during this time. Out of all this the final circuit as presented here was evolved.

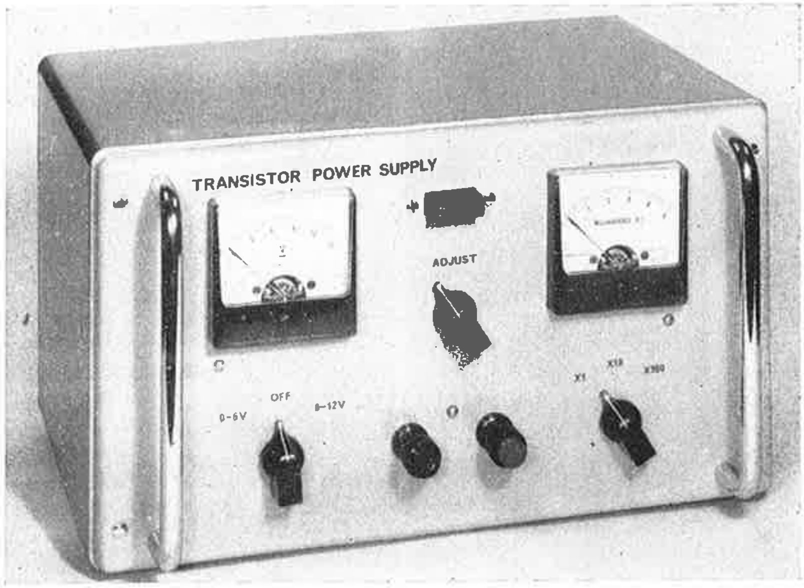
Firstly, the unit uses a standard filament or heater transformer, which is readily available. This is the PF162, which has two 6.3 volt 3 ampere windings, one of them being centre-tapped. The centre tap is not used in this application. One six volt winding only is used on one range, and both of them in series on the other range. This arrangement has the advantage that the power dissipated in the main output transistor on low voltages and high currents is reduced.

Having regard to the fact that the series resistance introduced into the system by the regulator transistor involves a certain voltage drop, and that this loss is of course increased as the output current is increased, the transformer chosen will deliver enough input to the filter and regulator section of the circuit for currents up to 500 ma. This figure is also the maximum rating for the small silicon diodes used as rectifiers in the circuit, so this figure was adopted as the maximum current rating.

The rectifier consists of two silicon diodes in a conventional voltage doubler rectifier arrangement. The regulating element in the circuit consists of two zener diodes, one only being in circuit on the low voltage range, and the two in series on the high range. The regulated voltage is also present between the emitter and ground of the 2N408 transistor, where the required voltage is tapped off by means of the manual voltage adjustment potentiometer. A fixed series resistor controls the lower limit of the higher range.

Metering

As in the previous power supply, an 0-15 volt meter is used to read the output of the unit. This was done partly to standardise on this component, and partly to allow some margin for over adjustment of the output voltage. Because the output current is limited to a maximum of 500 ma, and this unit, unlike the former unit, is likely to be used only on units such as radios,



Front view of the power supply

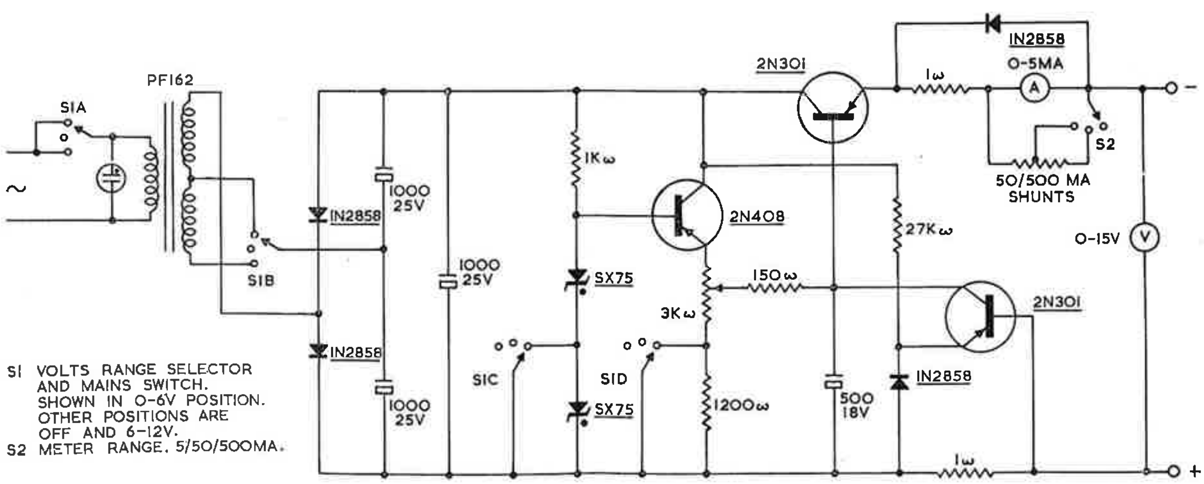
which consume small currents, an output current meter with a range of 5 ma was chosen. Shunts were then selected to provide alternative ranges of 50 ma and 500 ma. A silicon diode provides protection for the current meter, both in the event of the current exceeding the selected range, and in the event of a short circuit at the output terminals of the power supply.

Overload Protection

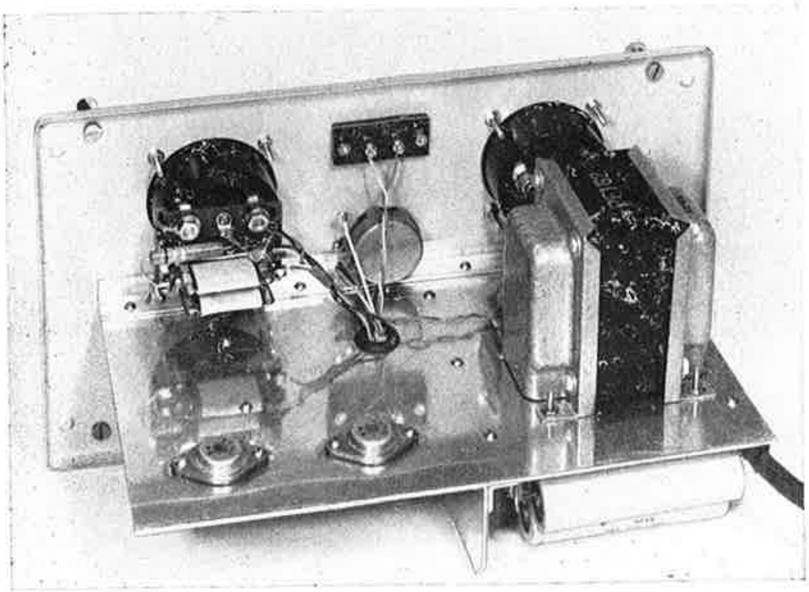
In addition to the overload protection provided for the output current meter, similar protection is also provided for the complete unit. This prevents costly damage to the unit, and is capable of withstanding a short circuit across the output terminals for a reasonable time.

The unit overload protection is afforded by means of a 2N301 power transistor, which operates under short circuit conditions to reduce the output voltage to a very low level, such that a damaging current cannot flow. In intermediate conditions between the normal full load output and a short circuit, the overload protection operates in the same way, but the reduction of voltage is less pronounced.

The reduction of voltage is achieved by taking the base of the regulating 2N301 towards ground, so reducing the output voltage. This results in increased dissipation both in that transistor, and in the other 2N301 which provides the protection initially.



Circuit diagram of the power supply featured in this article



Top rear view of the power supply with the case removed

The second or "overload" 2N301 is actually operating as a current-sensing device. It is biased into the non-conductive region, or at least into a condition where only a minute current flows between emitter and collector. The bias is derived from the forward voltage drop across a silicon diode, through which a small current is allowed to flow through the series resistor.

At the same time, the output current of the power supply passes through a low series resistor, the voltage drop across which is so arranged as to oppose the hold-off bias on the 2N301 transistor. Dependent on the value of this series resistor, a point will be reached as the output current is increased, where the voltage across the resistor overcomes the bias voltage from the diode, and increased conduction will take place in the transistor.

This arrangement has been extensively tested under various conditions, but of course more particularly under the imposition of short circuits. When a short is applied, the output voltage immediately falls to a very low value, which is of course dependent among other things on the actual value of the series resistor; when the short is removed, the circuit immediately restores itself to the condition obtaining before the arrival of the fault.

Remembering that the dissipation in the 2N301 transistors is steeply increased under short circuit conditions, the provision of heat sinks for these units should in theory be dictated by the highest dissipation that could be continuously caused in them. This however could be unrealistic, and a compromise has been sought. The heat sink provision in this unit, consisting merely of the 14 gauge chassis of the unit, is adequate both for normal operation and for short circuits of several minutes duration. This is considered satisfactory, as no-one is going to leave a short on the unit longer than necessary, and some minutes give plenty of time to detect that a short is present and to take remedial action.

Controls

As already mentioned, the output current meter is equipped with shunts to give ranges of 5, 50 and 500 ma F.S.D. The selection of the current range is by means of a switch. The power supply has two voltage ranges, 0-6 volts and 6-12 volts. The required range is selected by means of a switch. This switch also controls the mains input to the unit, and has a centre-off position. This arrangement avoids switching the secondary of the transformer with the power applied. The voltage output, within the selected range, is controlled by a potentiometer, so that any voltage in the range 0-12 volts can be selected. As in the case of the former unit, a neon indicator light provides positive indication when the unit is switched on.

Operation

The method of using this instrument arises of course from the descriptive sections above. There are however a couple of points that may be worth a mention. One concerns the output terminals; neither side of the supply output is grounded, so that when the unit is in use, either side can be grounded external to the instrument, as required.

It may also be noted that positive indication is present in the instrument in the event of an overload or short circuit, in that the output current meter will read full scale, and the output voltage will fall. The diode protection provided for the current meter will allow the meter to read full scale under overload conditions, in fact the meter pointer will travel to the end stop. This does not however mean that the protection is not present, as can be checked by measuring the meter current under these conditions.

The meter protection by-passes current from the meter in increasing measure as the output current increases. Although the meter may travel to the end stop and stay there, it is in fact carrying only a small excess current, well within its capability, whilst the larger portion of the current flows through the diode.

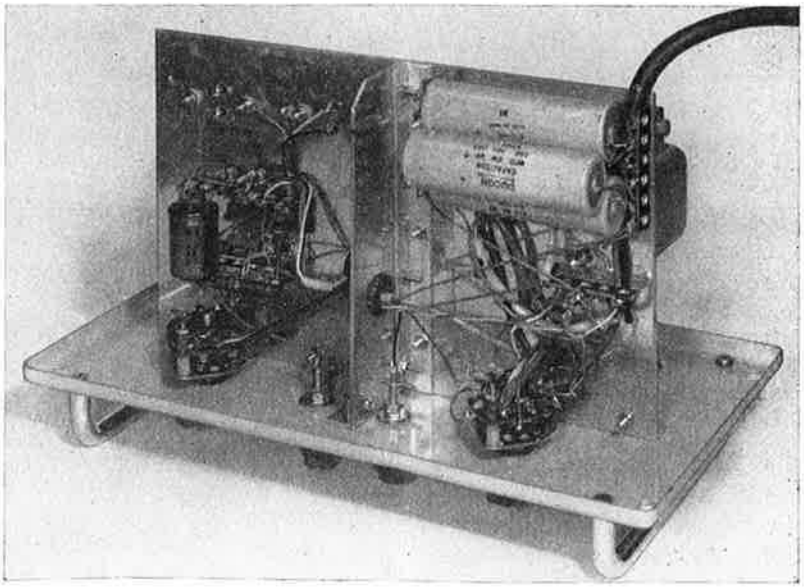
Construction

The complete instrument is constructed into a type 1490B metal cabinet with matching chrome handles; the finished appearance is very pleasing, as can be seen from the accompanying photographs. This is one of those instruments where the ratio of front panel space required to the bulk of the instrument is high; this prevents it being built into an even smaller box. The instrument is 12 inches long, 7½ inches deep exclusive of knobs and handles, and 7½ inches high.

A matching chassis is available with the cabinet, but as the unit is very simple, this was not used on this occasion. A platform for the internally-mounted parts was formed with a flat section of 14 gauge aluminium, affixed to the rear of the front panel with a length of ½″ aluminium angle. A two-inch deep partition was fixed underneath, running from front to back, to add support for the platform and to "firm up" the assembly.

The two power transistors are mounted through the chassis, which acts as a heat sink for them. Other small components are mounted with the aid of tag strips, as seen in the photographs. Two Master type S225 matching meters were used, the same type as we used in the earlier model. The voltmeter is calibrated 0-15 volts, partly to standardise with the earlier unit, and partly to allow a margin for adjustment of the voltage over the nominal 12 volts. The shunts provided with the milliammeter are mounted on a section of tag strip. This in turn is fastened to the back of the meter using the terminals. An extra tag was fixed to the shunt assembly to assist in mounting the series resistor and silicon diode which afford protection for the meter in the event of overload or short circuits.

The two switches used are not to be confused with ordinary wafer switches. The fact that one of them has to carry the mains input to the power supply called for something a little more robust and with a suitable voltage rating. Paton type "A" switches were used, that for the voltage selector and mains switch being a 4-pole, 3-way unit, whilst that for the meter switch requires only a single pole, 3-way. Similar switches were used in both positions, although the meter selector could be a much lighter type of switch



Underside view of the power supply removed from the case

if desired. Readers are very observant we find; before they write in to tell us that we are using a 2-pole, 3-way switch for the meter selector, we hasten to admit it. In fact only one pole is used. The switch was ordered at a time when the design of the unit was not complete and it was thought that a further pole might be needed; as it turned out it was not.

No parts list is supplied for this unit, following our usual practice for the smaller jobs. Major components have already been described in the text, whilst other components values are inserted in the circuit diagram.

Performance

The nominal voltage ranges can be covered by means of the selector switch and the manual control over any load current between zero and the rated full output of 500 ma. The regulation, as one may expect, is not as good as it was with the earlier unit, which was a much more robust type of thing. This is not however considered a disadvantage, as large variations of load current are not often met with in practice. In the worst case, setting the unit without load for an output of 12 volts, and then applying the full load current of 500 ma, the output voltage falls to just under 9 volts; this fall is easily made up by adjustment of the output control.

The ripple content in the output is very low, being of the order of three millivolts. The ripple content appears substantially constant irrespective of load conditions. In using the power supply, it will be found that there is a barely perceptible delay between the operation of the manual voltage adjustment and the voltmeter coming to rest, dependent on the operating conditions obtaining at the time. This is due to the fact that a change of voltage requires an adjustment of the charge on the 500 mfd capacitor connected between the base of the main 2N301 and the positive side of the supply. It is this capacitor in the main that produces the very low ripple output from the unit. For those who are experimentally minded, the delay is increased as the capacitor is made larger, but without any further noticeable reduction in the ripple voltage.

Summary

This unit will find its best application in cases where fairly steady loads are being applied, as in the testing of small amplifiers, radios, pre-amplifiers and similar apparatus. The metering included will materially assist in the use of the unit, whilst the overload-proof feature will be found most valuable. The cost of the unit has been held to a minimum consistent with providing a sound unit with a practical application.

NUVISTORS

Continued from page 166

Although larger values of circuit resistance can sometimes be used, particularly in cathode-follower designs, circuit designers should always seek advice from the valve manufacturer if they wish to exceed published ratings in a particular application.

The maximum metal-shell temperature rating of 250 degrees Centigrade for nuvistors allows operation at chassis temperatures up to 170 degrees Centigrade for the 7587, 185 degrees Centigrade for the 7586 and 7895, 200 degrees Centigrade for the 8056, and 210 degrees Centigrade for the 8058. A separate scale of actual nuvistor metal-shell temperatures is also included in the nomographs. Measurement of actual shell temperature is recommended in printed-circuit applications and in other applications where high packaging density or wide environmental temperature ranges may create hot spots within the equipment.

(With acknowledgements to RCA)

Editor .... **Bernard J. Simpson**

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